

THE LARGE-SCALE ECONOMIC AND INDUSTRIAL SYSTEMS STRUCTURAL AND ORGANIZATIONAL SUSTAINABILITY ENSURING THROUGH ENTERPRISE ENGINEERING METHODOLOGY

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Abstract. In the new global economy enterprise integration and collaboration has become a central issue for achieving the market success, which is why the significant amount of the large-scale enterprise and industrial systems (LSEIS) has appeared. Despite LSEIS efficacy, their participants suffer from several major drawbacks: the limited rationality and opportunistic behavior from other LSEIS participants, the insufficient coordination because of the possibility of setting the different goals than consolidated LSEIS vision. All these deficiencies lead LSEIS towards to losing the stability of functioning and require developing the approach for its avoiding. Given this, this article aims to propose the conceptual, theoretical framework for the ensuring the structural and organizational sustainability of LSEIS functioning. The achieving of this aims based on the author's hypothesis about the ensuring LSEIS sustainability through the optimization of the LSEIS participants' interaction parameters and establishing the set of business rules accepted by all members of an integrated organization. In order to prove this hypothesis was used the DEMO (Design and Engineering Methodology for Organizations) methodology.

Keywords. Design and engineering methodology for organizations, large scale enterprise and industrial systems, enterprise interaction, organizing, enterprise ontology, structural and organizational sustainability, enterprise engineering

I. Introduction. In recent years, there has been an increasing interest in enterprise collaboration and developing the integration business structure. Increasing the interaction scope and amount of integration spheres between enterprises gives to such participants of the integration process the possibility of making an influence on the parameters of market functioning. Just existence of such an opportunity for market

power obtaining has led to the large-scale enterprise and industrial systems (LSEIS) appearance. From one side the LSEIS get a set of advantages such as reduction of competition or cost minimization which based on the scale economies or achieving synergy. From the other side, the LSEIS is a very complex and because of this is a very complicated structure that requires reducing this complexity. Only in case of such reducing LSEIS can achieve its goal by making the decision process more transparent for LSEIS participants. So increasing the decisions transparency leads to decreasing the LSEIS participants' opportunism level. Moreover, increasing transparency is the keystone in achieving the structural stability of the organization because of the appearance of possibility to develop the strict rules for LSEIS activity regulation.

II. Statement of the problem. It was stated that establishing the rules for LSEIS participants functioning could lead to increasing the sustainability of the integrated business structure in general. Proving this statement requires combining the results of researches in different economic areas. Most studies in organizational sustainability have only been focused on a level of the separate enterprise, not on the integrated business structure. Moreover, the research to date has tended to focus on enterprise economic or financial sustainability rather than investigation the relationship between the enterprise structure and its sustainability. In this case, it is fair to point the K. Hausman [6] research in the sphere of enterprise architecture sustainability where the author tried to find alignment with the concepts of sustainability and architecture. However, this research connected only the sphere of information technologies and required expansion to the remaining areas of the enterprise economy. Another outstanding research was conducted by S. Kortmann [9] who explored the relationship between organizational structure and organizational ambidexterity. S. Kortmann has proved the necessity to consider the enterprise strategy as «a set of adaption practices which can explain sustainable competitive advantage» [9, c. 149] Unfortunately, this author shifted the focus of his attention to strategic management instead of the declared organizational structures. Moreover, he did not take into account the integrated business structure peculiarity.

In contrary to the K. Hausman [6] and S. Kortmann [9] research there is a large

volume of published studies describing the economic integration process. Usually, such studies consider or the large integration entities and corporate governance or the integration structures that based on the relative contracting and supply chain management. If we take as a base the sustainability viewpoint, the main problem of the mentioned studies is a lack of complexity. Studies dedicated to corporate governance usually do not consider the sustainability aspect. The research of F. Lessambo [11] is very representative in such a situation. This author has studied the role of audit and board oversight that definitely have influence on sustainability level but the sustainability concept had been left out of the main part of F. Lessambo research. However, the sustainability researches [6; 9] have left their attention out of the board of directors influence. The same situation can be established towards the H. Elbardan, A. Othman, and R. Kholeif [5] or the L. Camarinha-Matos [2] studies, which talking about the decision coordination but didn't pay enough attention to discover the influence of this decision on the level of integrated structure sustainability.

It should be noticed two more drawbacks inherent to the research works which directly dealing with corporate sustainability or with the sustainability of integrated business structure. These drawbacks have interdependent influence each other. One of these drawbacks connected with the necessity to take into account as many types of sustainability as possible with orienting at the same time on the integration properties of the corporate structure. For example, A. M. Brockett and Z. Rezaee [1] in their research invented the new concept of «sustainability reporting» and described the role of the corporation in Society. Nevertheless, their proposal is based on the financial ground that is why this research needed some enhancement. Very often corporate sustainability is considered by the authors as a synonym for the social responsibility like in M. Camilleri [3] research. Such an approach is not entirely correct and therefore requires expansion. The other drawback connected with the desire to cover in one research the whole pack of possible types of integration relations between the economics entities inside the integrated business structure, which is very hard because of the diversity of these relations nature.

Thus, looking at the mentioned studies lead to one obvious solution, which

supposes ensuring mutual penetration of the results of the listed studies. Under this solution, the different types of integrated or corporate business structure will describe as large-scale enterprise and industrial systems (LSEIS). We offer to consider all these types of integrated or organizational structure as a particular case of LSEIS. Feasibility of such approach was proved at the beginning of this article. In addition, the proof of this proposal based on the A. Pylypenko and A. Litvinenko [13] research. These authors have offered the way to describe the architectural design and the institutional rules for LSEIS functioning. These proposal has received the continuation in this article author's research [14] where were presented the way to combine the architectural approach to LSEIS representing with the sustainability concept and with the resource approach to strategic management. This idea requires the practical implementation and the further theoretical justifications from the viewpoint of different types of sustainability. This is what has determined the purpose of the article.

The purpose of this paper is to develop the methodical approach to ensure the structural and organizational sustainability of the large-scale economic and industrial systems by modeling the industrial system participants' interaction and establishing the rules for the realization of these interactions.

III. Results. As the base for established goal realization will have been used the expansion of authors' proposal [14] of LSEIS representation through its architectural description. First, this expansion assume focusing on sustainability maintaining through the business rules implementing and control their adherence. In this case, LSEIS can be described in the following way:

$$LSEIS = \langle ARCH, IBASE, BRUL \rangle \quad (1)$$

ARCH – the architectural description of large-scale economic and industrial system that should be correspond with one of the systems architectural description standards.

IBASE – the basis for integrated structure appearance that includes the list of enterprise within the LSEIS and the list of integration core elements, which could be the resources, knowledge, capital, competence, production capacity, etc.

BRUL – the set of business rules that are governing the LSEIS participants' behavior.

Second. The expansion of authors' proposal [14] also involves usage the DEMO-

methodology (Design and Engineering Methodology for Organizations, which developed and provided by Enterprise Engineering Institute) for achieving the LSEIS structural sustainability. Unlike the existent approach, DEMO will be used for setting the formula (1) parameters. The bases of DEMO methodology is presented in J. Dietz [4] research where the enterprise ontology is described, and examples of its usage are given. DEMO has one important advantage: the whole methodology has oriented on the roles of actors, which can be the LSEIS participants and the set of stakeholders. Such an approach has given the possibility to identify the LSEIS members, to define their relations with the environment, and to establish the base for such relations appearance. As we can see, all of these given possibilities connected with the formula (1) components. According to J. Dietz [4, p. 145] the LSEID can be represented as a network of responsibilities and interaction. He also had mentioned that DEMO could constitute the essence of the organization. DEMO models are coherent consistent comprehensive concise. That is why they are best suited for establishing the rules of corporate interaction within the LSEIS. This type of rules was mention at the beginning of the article in connection with the H. Elbardan, A. Othman, R. Kholeif [5] research. Now the instrument of these rules creation has been defined.

A number of researchers have developed and improved the DEMO methodology. The J. Dietz followers have used his idea for working with the enterprise architecture or for the engineering processes implementation. For example, M. Land [10] reflected the links between DEMO models and other tools for building an enterprise architecture such as ArchiMate [15] or YAWL (Yet Another Workflow Language [4]). T. Janssen [8], in turn, introduced the concept of «Enterprise Engineering» and presented the examples of different DEMO models connection one with each other. According to T. Janssen Enterprise Engineering is about «mapping the crucial agreements and activities that make up a cooperation pattern, and research its possible flaws» [8, p. vii]. J. Hoogervorst [7], likewise the others, represented the enterprise design through its architecture and communications with the environments. He also used the DEMO modeling for describing the interaction of different enterprise architecture elements that supported and oriented on such an architecture.

Despite all of given research in DEMO modeling, all of given achievements works only with a particular enterprise. Moreover, most of them should be extended to the LSEIS level. There is one research explicitly connected to the LSEIS where A. Pylypenko and A. Litvinenko [13, p. 76-77] use ORM-methodology (Object-Role Modeling) for generating the institutional rules and describing the architectural design of large-scale economic and industrial systems. In this case, should be noticed the DEMO superiority which contained in a possibility to combine the models with different content and level of detail. Using DEMO facilitates the process of borders defining for LSEIS based on the mild integration such as cluster structure or supply chain. Also using DEMO gives the possibility to combine the corporate governance requirements with the structural sustainability provision even when corporate governance requirements defined not only by the board of directors, like in F. Lessambo [11] research, but by when such types of requirements consist the interest from the expanded list of stakeholders. This is one of the best possibilities to gain the level of LSEIS sustainability.

The main advantage of DEMO methodology lay on the plane of different models combining. The set of DEMO models described the one or another aspect of the LSEIS participant interaction while other models detail the rest aspects of LSEIS functioning. DEMO is a high-level model. Because of this became possible to establish the logic of maintaining structural stability. The practical implementation of this logic would be realized by developing other models with usage more precisely approach, for example, the BPMN. The main idea of DEMO modeling is a reduction of complexity. Only such reduction can give the whole view of LSEIS and create a foundation for maintaining stability. Therefore, the first model, which should be created, is a high-level conceptual model that showed the main actors within LSEIS and the fundamental interaction between them. Figure 1 shows the core of LSEIS. This is a high-level diagram that represented the role of main LSEIS actors and according to J. Dietz [4] has called the «Global Actor Transaction Diagram». The symbols that have been used at Figure 1 are also taken from J. Dietz [4, p. 134] book. Because of this, there are no explanation of their meaning in this article. It should be mentioned, that the model shown at Figure 1 was made by using the free online modeling tool and repository «Modelworld» [12].

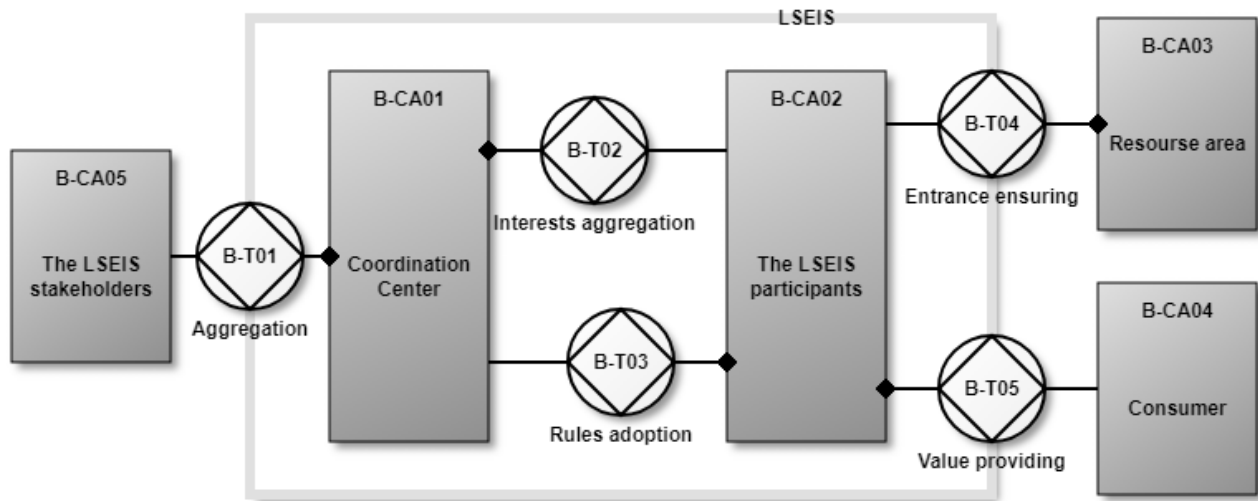


Fig. 1. Global actor translation diagram for the large-scale economic and industrial systems as implementation of *ARCH* component from formula (1)

DEMO models shows who is responsible for what. The violation of such responsibility distribution leads to the LSEIS sustainability level falling. Therefore, LSEIS could ensure the level of its organizational and structural sustainability by establishing the rules for inner transaction. The example of such rules represented in Table 1, which according to DEMO methodology called «Transaction Result Table». This table also shows the interrelation between components of formula (1) and global actor translation diagram from Figure 1.

Table 1

General transaction result table for the large-scale economic and industrial systems as implementation of *BRULE* component from formula (1)

Transaction type	Result type	Business rule
T01 – the LSEIS stakeholders interests aggregation	R01 – the place of LSEIS in the global environment has been achieved	The formalized description of LSEIS partners requirements and interaction parameters
T02 – the LSEIS participants interests aggregation	R02 – institutional rules adoption by participants	The definition and description the LSEIS business-policy
T03 – the rules of interaction adoption and implementation	R03 – the gap between goals of LSEIS participants	The local rules that accepted by particular LSEIS participant
T04 – the business process entrance ensuring	R04 – recourse management within supply chain	Rules for timing, completeness and quality of resources supply
T05 – value manufacturing, providing, and transferring	R05 – the consolidated income of LSEIS and its participants increasing	The set of indicative indicators in marketing, production, finance, quality etc.

The ensuring LSEIS sustainability requires the rules from Table 1 should be translated to subordinate levels of corporate architecture. In the case will have been occurred the increasing the actor roles amount and these roles specification, which lead to clarifying the requirement for LSEIS sustainability. Figure 2 shows such increasing the number of LSEIS actor roles. In this case, according to the author hypothesis, the whole amount of actors has formed the LSEIS integration basis, which described by formula (1).

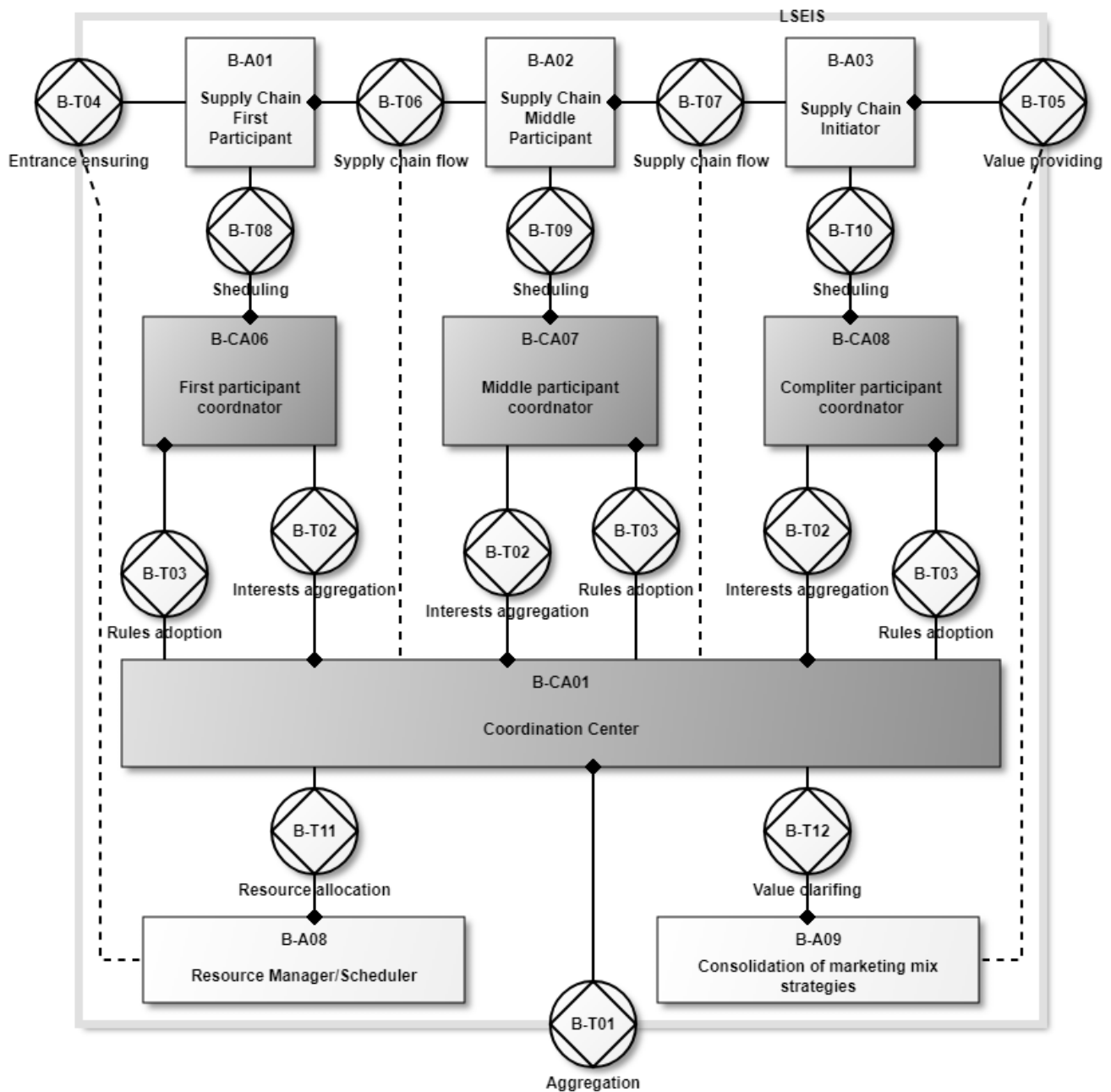


Fig. 2. Actor translation diagram for the large-scale economic and industrial systems as implementation of *IBASE* component from formula (1)

The number of LSEIS actors increasing from Figure 2 gives also the possibility for clarifying the information from Table 1. As a result, the new set of business rules for keeping the LSEIS structural sustainability could be established. Table 2 has contained the example of these additional business rules.

Table 2

Transaction result table for the large-scale economic and industrial systems
as implementation of *BRULE* component from formula (1)

Transaction type	Result type	Business rule
T06 – the created value transfer inside the LESIS	R06 – the output of the first chain of the supply chain	The basic logistics rules related to the business process parameters and adopted by LSEIS
T07 – the created value transfer inside the LESIS	R07 – the output of the next chain of the supply chain	
T08 – request to the LSEIS about the business process features and parameters	R08 – the consolidated with LSEIS vision of the business process flow	The set of business rules for each LSEIS participants, which define the requirements to the business process realization at the specific part of the supply chain
T09 – scheduling the work flow and estimating the gap between the expected value	R09 – the measures to improve the business process parameters	
T10 – request for the created value customization	R10 – the list of the created value attributes	
T11 – request for the resource spreading among the LSEIC participants	R11 – the resource allocation plan among the LSEIC participants	Clarifying the resource distribution norm and the logistic conflicts avoiding
T12 – request for clarifying the marketing mix strategy for supply chain participants	R12 – the consolidated marketing mix strategy and it reflection to the each LSEIS participants	Transformation of the marketing mix elements into the business rules for the certain level of LSEIS

Thus, the mechanism creation for rules maintaining from Table 1 and Table 2 will precisely ensure large-scale economic and industrial system structural and organizational sustainability. Such sustainability will be achieved through the raising the level of communication maturity within the large-scale system and between this system and the whole list of its stakeholders.

IV. Conclusions. This study has shown the way for ensuring the structural and organizational sustainability of the large-scale economic and industrial systems through developing the enterprise ontology. The necessity of such an approach is based on limited rationality and opportunistic behavior existents among the large-scale

enterprise and industrial systems participants. The LSEIS could lose the appropriate level of structural sustainability because of insufficient coordination. This statement is true because of the possibility for LSEIS participants to set the different goals than consolidated LSEIS vision. Given this, one of the more significant finding to emerge from this study is a possibility to ensure the LSEIS sustainability through the optimization of the LSEIS participants' interaction parameters and establishing the set of business rules accepted by all members of an integrated organization. Our funding in this paper are reflected to usage the DEMO (Design and Engineering Methodology for Organizations) methodology. Usage the DEMO gives the possibility for describing the LSEIS through the combination of its architectural description represented by the set of elementary actors' roles and by the integration bases. Establishing the transactions between the actors' roles helps to determine the set of business rules that are governing the LSEIS participant.

This research has thrown up many questions in need of further investigation. The primary purpose of DEMO modeling is a settlement of the collaboration between the business architecture and the information systems. This study has described only business architecture. Thus, the future study will investigate the way to establish and develop such collaboration with the LSEIS information systems. It would be interesting to expand to LSEIS integration based on formula (1) by adding such economic objects like competence, knowledge and human capital. Further research might explore the continuous mapping of given models to the subordinate levels of LSEIS representation. It should be mentioned that Table 1 and Table 2 do not describe the rules, but determine the areas in which these rules can be created. Therefore, the further research will be about the development of the rules with the strict wording.

Literature

1. Brockett A.M. Corporate Sustainability. Integrating Performance and Reporting / A.M. Brockett, Z. Rezaee. – New Jersey: John Wiley & Sons, Inc., 2012. – 338 p.
2. Camarinha-Matos L. Collaborative networks: reference modelling / L. Camarinha-Matos. – New York: Springer, 2008. – 334 p.

3. Camilleri M.A. Corporate Sustainability, Social Responsibility and Environmental Management: An Introduction to Theory and Practice with Case Studies / M.A. Camilleri. – The Netherlands: Springer, 2017. – 207 p.
4. Dietz J. Enterprise Ontology. Theory and Methodology / J. Dietz. – The Netherlands: Springer, 2006. – 240 p.
5. Elbardan H. Enterprise Resource Planning, Corporate Governance and Internal Auditing. An Institutional Perspective / H. Elbardan, A. Othman, R. Kholeif. – Switzerland: Palgrave Macmillan, 2017. – 446 p.
6. Hausman K. Sustainable Enterprise Architecture / K. Hausman. – New York: CRC Press, 2011. – 291 p.
7. Hoogervorst J. Enterprise Governance and Enterprise Engineering / J. Hoogervorst. – The Netherlands: Springer, 2009. – 443 p.
8. Janssen T. Enterprise Engineering. Sustained Improvement of Organizations / T. Janssen. – The Netherlands: Springer, 2016. – 148 p.
9. Kortmann S. The Relationship between Organizational Structure and Organizational Ambidexterity. A Comparison between Manufacturing and Service Firm / S. Kortmann. – Germany: Springer Gabler, 2012. – 183 p.
10. Land M. Enterprise Architecture. Creating Value by Informed Governance / M. Land, E. Proper, M. Waage. – The Netherlands: Springer, 2009. – 154 p.
11. Lessambo F.I. The International Corporate Governance System. Audit Roles and Board Oversight / F.I. Lessambo. – London: Palgrave Macmillan, 2014. – 482 p.
12. Modelworld [Электронный ресурс]. – URL: <http://www.modelworld.nl/>.
13. Pylypenko A. Institutional and architectural design of organizational development of large-scale economic and industrial systems / A. Pylypenko, A. Litvinenko // Economic Annals-XXI. – 2017. – № 165(5-6). – P. 75-79.
14. Shmatko N. The conceptual background for facilitation of large-scale economic and production systems' sustainability / N. Shmatko // Economics of development. – 2017. – № 4(84). – P. 16-27.
15. Wierda G. Mastering ArchiMate. Instruction to the ArchiMate enterprise architecture modeling language / G. Wierda. – The Netherlands: R&A, 2017. – 256 p.